IMPLANT PROSTHODONTICS: Beginning with the end in mind!

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INTRODUCTION

Prosthetically driven implant dentistry is now considered to be the minimum standard of care in contemporary dental science. There is a lot to think and plan for from a prosthetic standpoint when looking at a patient who is a potential candidate for implant driven tooth replacement. The clinician who plans the implant case must first let the restorative mind in him/her speak up. The position where the missing tooth ultimately belongs should be decided first. Thereafter an assessment should be done to see if there is bone available to put the implant in such an ideal position that the loads will be transmitted from the prosthetic tooth to the underlying implant along the long axis of the implant **(Figure 1)**. When no available bone is found in the ideal implant position the next consideration should be whether to augment bone and get the host site ready to receive the implant in ideal position or to abort implant placement as an option altogether. There is a third option, to modify the treatment plan and place implant where the available bone is and accept non axial load that could come with its own set of biomechanical and technical problems thereby jeopardizing the longevity of the implants. It would be prudent to avoid fixed implant prostheses in such situations in certain types of cases.

This article aims to highlight the thought process behind prosthetically driven implant dentistry and deals briefly with the factors to consider in deciding the type of prostheses for implant patients.

FIG 1: Implant planned to have load transfer along its long axis from the proposed final tooth

FIG 2: Acrylic plate with ball bearing to be used during OPG

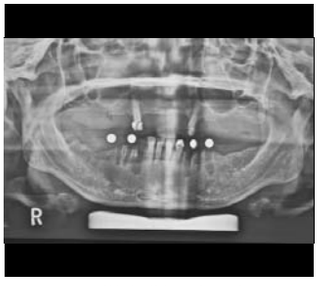

FIG 3: OPG with ball bearings to calculate distortion

FIG 4: Radiographic guide with radioopaque teeth, worn during dental scan

FIG 5: Scan without radiopaque teeth will make it difficult to find this exact slice location in the mouth

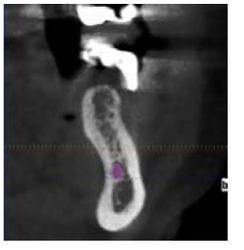

FIG 6: Scan done with radiopaque teeth depicting exact volume of bone available in molar region

ASPECTS OF PROSTHETICALLY DRIVEN IMPLANT DENTISTRY

There are several aspects to consider when restorative mindset is at the forefront for treatment planning of implant cases. For the sake of simplicity in this article we divide these into two categories:

1. Pre surgical implant prosthodontics

FIG 7: Existing denture modified to make surgical guide

FIG 8: Existing denture duplicated and modified to make surgical guide

FIG 9: Surgical guide in use to depict location of implant in relation to proposed teeth

FIG 10: Vaccuform matrix modified to be used as a surgical guide

FIG 11: Surgical guide depicting position of free gingival margin of proposed final tooth to enable correct depth of placement of implant

FIG 12: Final result of case shown in Fig 11

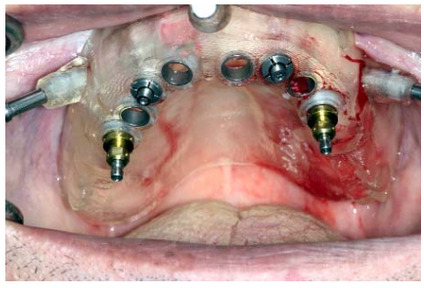

FIG 13: Surgical stent carrying information about 3D implant placement and allowing placement of implant through it

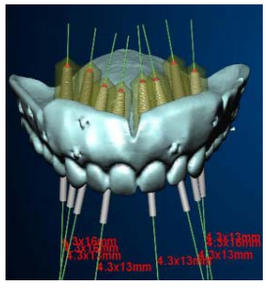

FIG 14: Planning steps for virtual implant positions and generating a surgical guide

FIG 15: Screw Retained Restoration, Implant Level

FIG 16: Cement Retained Restoration

2. Decision on the type of implant prostheses

PRE SURGICAL IMPLANT PROSTHODONTICS

Stents

A stent in implant dentistry would be any appliance fabricated for the patient that will depict the position of final teeth to be replaced and enable the clinician to gather information about proposed implant site so as to aid in clinical aspects of implant planning and surgery. Depending on the mode of use these would be of two types:

1. Radiographic Stents

A radiographic stent, also known as a diagnostic stent, is fabricated prior to sending the patient for a diagnostic radiograph or a CT scan. As we know all radiographs may show distortions. Some radiographs like Orthopantomographs show distortions in height of the available bone. A novice clinician may read the height of available bone directly from an uncalibrated OPG and make an erroneous calculation regarding the length of the proposed implant. The simplest method to use is to have radio opaque markers (ball bearing's) of known diameter when taking IOPA or OPG for implant patients **(Figures 2** and **3)**. The distortion in the diameter of the marker will reveal the actual length of bone using the formula shown in **Table 1.**

Another method of fabricating radiographic guides specifically useful for CT scans is the use of radio opaque teeth in a denture set up made for the missing teeth **(Figure 4)**. A routine dental scan will give the accurate information of the patient bone morphology that is available for surgical implant placement, but after analyzing the scan it always becomes difficult for the surgeon, during implant placement, to identify the exact location where the available bone was as found on the scan **(Figure 5)**. Radio opaque teeth in a radiographic stent during scanning will give exact location of the available bone in relation to a particular tooth in the radiographic guide that will then be modified into a surgical stent **(Figure 6)**.

Table 1: Formula used to calculate distortion in x rays

$$\text{Actual length of Bone} = \frac{\text{Actual diameter of marker} \times \text{Radiographic length of bone}}{\text{Radiographic diameter of marker}}$$

2. Surgical Stents

A surgical stent is used during implant placement to allow the operator to have a specific guideline regarding the position or location of the final tooth, so that he can place the implant appropriately from a prosthetic standpoint.

Based on the degree of information generated from a surgical stent they can be of following types:

a. Those that provide a guideline for the mesiodistal and/or buccolingual position of the implant.

These are simple stents that can be duplicated from the patients existing denture **(Figure 7, 8, 9)** or made from a stone model that is generated by duplicating a diagnostic wax up of the missing teeth. A vaccuform suck down matrix is fabricated on this stone model and can be trimmed from buccal or lingual aspect to allow visualization of the position of the pilot drill **(Figure 10)**. Once the entry point of the implants is marked on the crest, the stent is removed and rest of the drilling protocol is carried out freehand.

b. Those that provide a guideline for mesiodistal, buccolingual and occlusocervical position of the implant **(Figure 11** and **12)**.

These stents give the crucial guideline regarding the depth of implant placement. It is of great value in the anterior zone. This stent will generally carry the information that depicts the proposed free gingival margin of the final tooth. The depth of the prosthetic platform of a bone level implant is ideally placed 3mm apical to the proposed free gingival margin of the final tooth, so as to achieve a correct emergence profile. There are other factors like tissue biotype and diameter of the implant being placed and the width of

FIG 17: Transmucosal components on which abutment level prostheses will be Screwed on

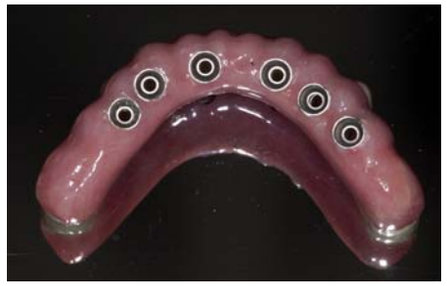

FIG 18: Abutment level prostheses

FIG 19: Reduced interarch space in molar region could be an indication for screw retained restoration

FIG 20: Excessive Interarch distance could be steered towards a screw retained prostheses

FIG 21: Screw access holes from labial structure of abutment

FIG 22: Screw retained prostheses with implants placed with flexibility in mesio distal position still not compromizing final esthetics

tooth being replaced that will enable determination of how deep an implant should be placed. The surgeon has to take these into consideration and decide the depth of final placement of the implant.

c. Those that provide a guideline for all of the above plus the angulations of the proposed implant but do not allow more than pilot drill to drill through.

These surgical stents will have metallic tubing inserted in them which will guide the pilot drill in its initial approach in the bone. Routine acrylic stents do not have these metallic tubing's and hence the surgeon can mark a purchase point on the bone and then drill freehand at whatever angle he chooses to enter into the bone as per local conditions. With these stents the commitment on the position of implant and the angle at which the drilling will be done is made on the model. When this is done in an inaccurate manner, the surgeon at times may realize that the initiation of the osteotomy has been too far buccal or lingual or at a wrong angle. Thus caution is advised with these stents especially if they are made free hand. Having said that, it is prudent not to use the pilot drill through an access hole made in acrylic in some types of stents that do not have a metallic sleeve as the acrylic shavings generated during drilling can get carried in the osteotomy and go unnoticed. That would be a catastrophic error against osseointegration of the implant.

d. Those that provide for all of the above and are designed to place the implant through them before they are removed from the mouth **(Figure 13)**.

Theoretically this would be an ideal stent as once the stent is fixated in place with screws they would be removed only after the implant is in its final position. This way the distance between the implants, the depth of the implants as well as their angulations' in bone can be predictably achieved with a certain level of accuracy. These stents could be bone supported, mucosa supported or supported on mini implants.

Fabrication of these stents requires the patient to get a scan done of the jaw with the denture (radiographic guide) in place and then a scan done of the denture by itself. Using a DICOM III (Digital Imaging and Communications in Medicine) format the data from the scan can be reconstructed in special software made for that purpose. The planning of implants **(Figure 14)** can be done in a virtual environment as per the prosthetic guidelines and then a virtual surgical guide is designed with the proposed positions of the implants finalized within its structure. The surgical guide thus generated will be used by the clinician to place the implants. There are three different techniques used to fabricate drill guides using software: Stereo lithographic, model based (CAM) and digital (CAD/CAM). Most commercially available planning software packages are open source. However, the guided drills and guided implant transfer coping are not always provided for the different implant systems and need to be purchased from implant specific manufacturers.

Recent studies have conclusively proved that there are mean errors at entry point and final position of the implant in the patients' mouth as compared to the original planning. A few millimeters of such errors could leave a patient with a potentially hazardous surgical complication. As with any new technology, case selection and meticulous attention to detail is advised with using computer designed and manufactured stents.

TYPES OF PROSTHESIS ON IMPLANTS

All patients will want fixed teeth on implants. It is up to the clinician to decide if that is the right type of prosthesis for the patients' bone condition, need and dexterity and budget. This section aims to put certain issues regarding selection of prostheses in perspective so that an informed decision can be made regarding the type of prostheses for the patient. Implant prostheses can be broadly classified as:

Table 2: Comparision between screw retained and cement retained prostheses

Screw Retained Restorations	Cement Retained Restorations
Passivity	
Esthetics	
Micro gap colonization risk	Natural occlusal form
Retrievability	Cost
Retention	Angulation correction
Limited abutment height	Tilted implants
Cement inclusion risk	Ease of fabrication
Deep insertion of the implant	Access to posterior sites
Multiple abutment restorations	

FIG 23: Implants placed in perfect positions for cement retained prostheses

FIG 24: Final prostheses of case in Fig 23 showing no implant emerging in interdental areas

FIG 25: Milled framework screwed on to implants. The 12 individual crowns will be cemented on to this

FIG 26: Individual cemented crowns on struts fabricated on screw retained framework in Fig 25

A. Fixed prostheses
B. Removable prostheses

A. FIXED PROSTHESES

A fixed prosthesis on implants will be one that cannot be removed by the patient. These can be

- Screw retained or Cement retained **(Figures 15** and **16)**
- Implant level or Abutment level **(Figures 15, 17** and **18)**

Screw Retained Restorations

Advantages:

i. The single biggest advantage of a screw retained restorations is retrievability. As implant cases get more extensive and complex they may need professional maintenance due to biological or technical complications. At that point if the prostheses can be unscrewed and removed, maintenance done and prostheses re screwed back it will be a huge advantage as compared to cement retained solutions where it may become impossible to retrieve the prostheses when harder cements are used. It is often recommended to use softer cements in such cases. That is a great solution, only problem being that if the abutment height is less or extensive cantilevering is done on fewer implants it may become a big issue as the constant de-bonding of the prostheses will put immense pressure on the clinician to use hard cements and that will lead to irretrievability.

ii. Screw retained restorations are ideally suited for reduced or excessive interarch spaces **(Figures 19** and **20)** and when implants are placed at an angle to each other, either by design or by operator error.

iii. The problem of having to clean up excess cement or the danger of leaving a speck of cement unidentified is not there with screw retained restorations as they are relatively easier to deliver.

Cement Retained Restorations

Advantages:

i. The greatest advantage of cement retained restorations is the ease of fabrication and relatively low cost.

ii. In posterior areas with limited mouth opening, it is difficult to use a screw retained restoration as getting the screw through the screw access hole especially on the occlusal surface is a clinical challenge. Cement retained solutions surely offer some advantages here.

iii. Occlusion is easier to design in a cemented restoration. Having the screw access holes through the occlusal surfaces in screw retained restorations requires refinement of occlusion after delivery and that is an added step that is not required for cement retained restorations.

When we are discussing screw retained and cemented restoration the discussion would be incomplete if the surgical protocol for each is not touched upon.

For a single tooth restoration if the plan is to make a screw retained restoration, surgical implant placement has to be perfect in all 3 dimensions. If the implant is too buccal or palatal **(Figure 21)** it will jeopardize the ability to have the screw access hole in the right position such as the cingulum of an anterior tooth.

On the other hand in full arch cases there is a limited flexibility offered by screw retained option in surgical implant placement mainly in the mesiodistal position. The implants may be placed conveniently as per bone availability and still that would not become a prosthetic complication as the teeth will be set on the framework according to esthetic and phonetic needs **(Figure 22)**. The placement of implants in full arch situations where a cement retained option is thought of is more exacting as we do not want the abutment to emerge in the proposed interdental areas of the final prostheses **(Figures 23** and **24)** thus making hygiene difficult.

Both these type of restorations can be fought for and against by their proponents and opponents. It would be a boon if the advantages of both can be combined in the same prostheses and disadvantages almost eliminated. One such option is to have a screw retained metal frame work (milled framework preferred over casted base metal frameworks) with struts that resemble teeth prepared in an ideal way for crowns. On these struts individual ceramic fused to metal

crowns can be fabricated and cemented. During delivery of the prostheses the metallic framework is screwed in on the implants and individual crowns cemented thereafter. Thus the prosthesis is now retrievable and any breakage of veneering ceramic on the crowns would need remaking of that one crown rather than removal of the whole prostheses **(Figure 25** and **26)**

Implant Level or Abutment Level Prostheses

In fully edentulous arches, when placing bone level implants, an implant level prosthesis will be screwed on directly to the implant. An abutment level prosthesis would need a prefabricated transmucosal component that helps transfer the prosthetic platform from a submerged subgingival position to a supragingival area. The prostheses would then be directly screwed or cemented on to this transmucosal abutment. This is automatically achieved when tissue level implants have been used.

The advantage of abutment level prostheses is that the prosthetic phase is taken care of away from the crestal bone thus making it easier to handle delicate gingival tissues around implants. Also as the transmucosal components are screwed in once and not disengaged at every prosthetic step from the implant, thus the healing and adaptation of gingival attachment around the implants is better. Another important advantage of abutment level prostheses is that when implants are placed at an angle to each other, they will aid in achieving parallelism in the screw access paths.

B. REMOVABLE PROSTHESES

A removable prostheses is one that can be removed by the patient. For the sake of this discussion we will narrow down to fully edentulous cases only. All patients desire fixed implant anchored restorations. The advantages of these are that they psychologically feel like their own teeth. The main advantages for the dentist in such situations is that maintenance is generally lesser and overall longevity is good if the designing of the prostheses is done correctly and adequate number of implants are placed in adequate volume of bone.

The disadvantages of fixed implant anchored prostheses however are many. Difficulties in hygiene, nocturnal parafunction, problems with speech due to air escape from under the pontics in maxillary anterior region are few of the disadvantages. In cases

FIG 27: Implant retained tissue supported OVD

FIG 28: Implant retained and supported OVD

of severe atrophy of maxilla there is greater difficulty in providing lip support with the fixed prostheses. A removable implant retained overdenture on the other hand can easily provide the critical labial flange to provide better esthetics with lip support.

Overdentures overcome all these disadvantages of fixed prostheses and require generally lesser number of implants to achieve that. However they come with their own set of disadvantages. The main one being the need for very high maintenance in the long term. Problems mainly encountered are loss of retention due to fatigue and wear of retentive elements and also breakage of dentures that have been hollowed from within to house the retentive elements. As the patients find it difficult to visualize the final outcome it is necessary to have diagnostic set ups done with and without flanges to allow the patient to make an informed choice.

Implant overdentures can be of 2 types:

a.) Those that mainly derive retention from the implants **(Figure 27).**

b.) Those that derive retention, stability and support from the implants **(Figure 28).**

The former is known as implant retained-tissue supported overdenture and requires lesser number of implants. But the denture cannot be flangeless or palate free as the tissue coverage provides the crucial support. These types of overdentures may be splinted or unsplinted in the mandible. However in the maxilla, splinting of implants used in overdenture treatment is important as the bone is softer and forces are not always along the long axis of the implants.

The latter is known as implant supported overdenture and requires more number of implants to engage the prostheses rigidly thereby not allowing much movement of the prostheses. These types of overdentures are done in cases where the patient has sufficient bone and economic considerations would otherwise allow a fixed implant anchored prostheses but an overdenture is chosen over fixed implant anchored prostheses as the patient may have conditions in the jaw that require a removable prostheses.

Some of the factors that make overdentures a better option than fixed teeth can be enumerated as follows:

a.) Severe arch size discrepancy where the maxilla has resorbed and become significantly smaller **(Figure 29)** than the mandible. In these cases having fixed prostheses in normal occlusal relation would mean having big facial and buccal cantilevers that could lead to detrimental lateral forces on the maxillary implants.

b.) Patients with tendency towards nocturnal parafunction where having removable prostheses has distinct advantages and help in dissipation of forces that could otherwise, due to their continuous presence lead to technical complications within the implant system.

c.) Patients with exacting speech needs where having fixed prostheses can lead to air escape from under the anterior pontics between implants leading to difficulty in pronunciation of words that need interaction of tongue with the palate. An overdenture can take care of this situation as there would be an anterior flange to prevent air escape.

d.) Patients needing lip support for esthetics where a fixed restoration cannot provide adequate lip support due to absence of a labial flange in atrophied maxillae.

One of the main requirements for doing an implant overdenture is adequate Interarch space. A bar supported overdenture may need as much as 18mm of space from bone crest to opposing tooth **(Figure 30)** whereas a ball and socket will need about 8-9mm **(Figure 31)**. A locator attachment **(Figure 32)** will reduce the space needed to about 6-7mm.

DESIGNING ASPECTS OF IMPLANT PROSTHESES FOR FULLY EDENTULOUS ARCHES: CANTILEVERS

Any prostheses or its part that extends

FIG 29: Arch size discrepancy showing smaller maxilla ideally dealt with overdenture option

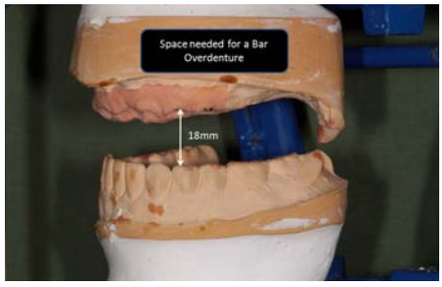

FIG 30: Minimum Interarch space for bar supported OVD

FIG 31: Ball and socket attachment

FIG 32: Locator attachments need less interarch space compared to others

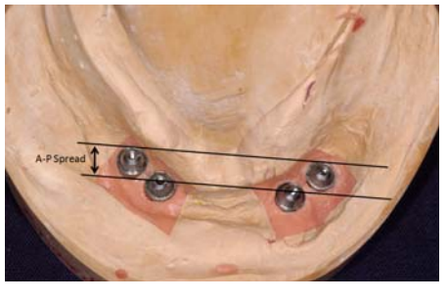

FIG 33: AP spread governed by distribution of implants

beyond the diameter of the implant is said to be a cantilever on that implant. Thus every implant can have a Buccal (facial), lingual, mesial and distal cantilever. Also there can be a vertical cantilever as the length of the restored teeth increases from the prosthetic platform of the implant. Treatment planning necessitates cantilevers in implant dentistry. The most abused of these cantilevers is the distal cantilever where the implant dentist places implants anteriorly in the jaw and replaces all anterior as well as posterior teeth. If done overzealously, these distal cantilevers will damage the implants either biologically or mechanically in the long term.

We follow the following guidelines in deciding the extent of distal cantilevers in full arch cases:

A-P Spread: The distance (x) between the line joining the distal surfaces of most distal implants and the centre of the mesial most implant is called AP spread **(Figure 33)**. Generally in the mandible for fully fixed prostheses we could cantilever up to 2 times the AP spread (2x). The biomechanics differs for maxilla, and this combined with softer bone and more lateral forces puts the maxillary prostheses at more risk if distal cantilevers are introduced. Thus for maxilla we would be very cautious with distal cantilevers and minimize them to a bare minimum. The guideline of AP spread is applied after taking other factors into account.

Force Factors: The dentition can be subjected to several other forces in addition to normal biting force. Any parafunction habits like bruxism and clenching or consumption of chewable tobacco etc. requires the distal cantilever to be reduced although AP spread allows it. Also conditions like tongue thrust can generate significant constant forces on the prostheses and requires cantilevers to be minimized.

The opposing dentition also governs the amount of forces on the cantilever. A complete denture would generate much lesser force than a natural dentition which in turn would generate lesser forces than an implant supported prostheses. As the force from opposing dentition is minimized the extent of distal cantilever can be increased within limits allowed by AP spread.

Type of Occlusal Material: Soft occlusal materials (Resin based) provide a damping effect to the force generated on the implant prostheses. This dissipates part of the occlusal force and transmits lesser force to the implant. Ceramic occlusal surfaces on the other hand transfer larger forces on the implants. Thus if a distal cantilever is to be designed, softer occlusal materials on passive fitting metal frameworks are advocated.

Diameter of implant inserted: If the forces on the implant are exerted by a distal cantilever it is prudent to have wider implants supporting the prostheses. Narrower implants (<3.5mm) not only have lesser bone implant contact but also have narrower screws supporting the abutments that could get biomechanically stressed.

Presence of other cantilevers: If there are other significant cantilevers (facial, lingual etc) present it is required to reduce the distal cantilever. Also in the maxillary prostheses due to the requirement of achieving ideal lip support there may be significant facial cantilever and sometimes even buccal cantilever that is employed to provide ideal overbite. This multiplies the forces on the prostheses and thus a reduction of distal cantilever helps reduce them. For every increase in the height of the prostheses by 1mm, the force due to leverage on the implant is increased by 20%. Thus in severe bone resorption with a long vertical cantilever it is prudent to cut down on distal cantilever.

CONCLUSION

This article touches upon several factors that are to be considered in treatment planning of implant cases from a restorative viewpoint. A thorough understanding of the biomechanics and load transfer has to be correlated with the patients local bone condition and their needs from the treatment so that a correct choice of prostheses can be made from a perspective of view of longevity and ease of maintenance.

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Dr. Ali Tunkiwala, completed BDS from Nair Hospital Dental College, followed by his Masters Degree in Prosthetic Dentistry from GDC, Mumbai in 1998. He is an Accredited Member of the American Academy of Cosmetic Dentistry and a Diplomate of International Congress of Oral Implantologist in 2005. He is a Fellow of The Indian Society of Oral Implantologists. Conferred with the ITI speaker status, he is the founder member and Co Director of the ITI Mumbai Seacoast Implant Study club that nurtures and guides young clinicians towards ethical and evidence based implant dentistry. Presently he maintains a Dental Practice at Santacruz (West) and conducts continuing education programs focusing on Implants, Esthetics and Full mouth rehabilitation. He can be reached at dralitunki@gmail.com.